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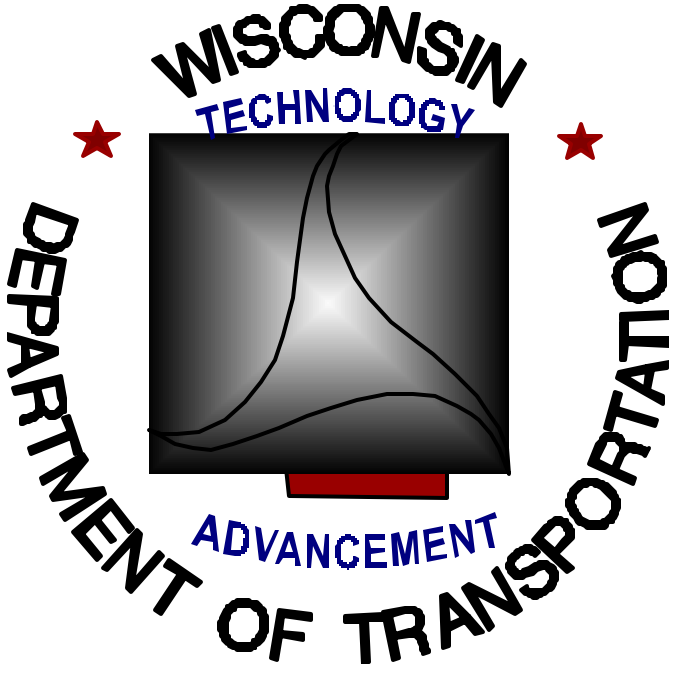
DURISOL NOISE BARRIERS



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DURISOL NOISE BARRIERS

FEDERAL EXPERIMENTAL PROJECT # WI 91-01

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INTRODUCTION

Durisol, manufactured by the Reinforced Earth Company, is a material designed to absorb incident sound energy rather than reflect it. Many miles of noise barriers made of Durisol have been constructed along highways in Canada and Europe. These barriers have endured the elements of harsh climates for nearly two decades with no apparent loss of acoustical effectiveness and no significant weather damage. Prior to this research study, Durisol had seen limited use in the United States and had never been used in Wisconsin.

DURISOL

Durisol is a hard, durable, open-celled material comprised of mineralized organic softwood shavings bonded together with portland cement. The porosity of the material allows for free draining of the panels, thus providing damage resistance to freeze/thaw cycles. Composite, precast panels, constructed of a reinforced concrete core, can be produced with the Durisol surface on one side or on both sides.

The panels are available in a variety of sizes to allow for quick and easy construction. The surfaces can be finished in a variety of textured patterns, enhancing the aesthetic characteristics, and can be integrally stained in any of the full range of standard concrete pigments or can be coated with a field-applied stain. The thicknesses of the panels vary, dependent upon the surfaces. A concrete core is typically 45 mm (1.75”) thick, while a flat Durisol surface is approximately 50 mm (2”) thick and a fluted surface is approximately 80 mm (3.25”) thick. Thus, a panel finished with a flat surface on one side and a fluted surface on the other side will be approximately 175 mm (7”) thick. Thin panels, 50 mm - 75 mm (2” - 3”) thick; however, which may be applied to existing walls for retrofit projects, are also available.

PROJECTS

Two construction projects were selected to perform in situ evaluations of Durisol's sound absorptive characteristics and overall performance. The first project, constructed in 1991, consisted of a single Durisol sound absorptive noise barrier erected on the west side of I-43, at Hampton Avenue in Milwaukee County (See Figure 1, page 11). The Durisol panels varied in sizes, but were typically 0.9 m (3 ft) high and 4.6 m (15 ft) long. The double sided sound absorptive panels were finished with a flat surface on both the residential side and the freeway side of the barrier and were sprayed in the field with a green sealer/stain. See photos on page 12.

Past literature reviews have indicated that certain applications of parallel noise barriers can create multiple reflections, degrading the overall performance of the barriers. In an attempt to evaluate Durisol's effectiveness regarding this issue, the second project consisted of parallel Durisol noise barriers. The barriers were constructed in 1992, along the east and west sides of I-94, between Grange Avenue and Layton Avenue in the City of Milwaukee (See Figure 1, page 11). These Durisol panels were also typically 0.9 m (3 ft) high and 4.6 m (15 ft) long, but were integrally pigmented in earth tones with some of the panels partially stained. The double sided sound absorptive panels had a flat surface on the residential side and a fluted surface on the freeway side of the barrier. See photos on page 13.

The dimensions of the barriers, provided by WisDOT's District 2, are shown below in Table 1.

Table 1: Durisol Noise Barrier Dimensions

Barrier Location	Height (Average)	Length	Area
I-43	5.9 m (19.5 ft)	410.6 m (1347 ft)	2438.6 m^2 (26,250 ft^2)
I-94 (East side)	6.1 m (19.9 ft)	1214 m (3984 ft)	7376.3 m^2 (79,400 ft^2)
I-94 (West side)	6.5 m (21.2 ft)	1248 m (4093 ft)	8063.7 m^2 (86,800 ft^2)

OBJECTIVES

The objectives of this study were to evaluate the performance of Durisol, with regards to:

- Construction Techniques
  - ⇒ Efficiencies/deficiencies
- Sound Reduction/Absorption Characteristics
  - ⇒ Laboratory Testing
  - ⇒ Field Testing
- Material Durability
  - ⇒ Surface abrasion
  - ⇒ Deicing chemical resistance
  - ⇒ Freeze/thaw
  - ⇒ Color retention
- Maintenance
  - ⇒ Efficiencies/deficiencies
- Costs

CONSTRUCTION TECHNIQUES

A report, *Construction Efficiencies of Durisol Sound Absorptive Noise Barriers*, documenting the construction phase of the barriers is on file. The results indicate that the Durisol panels were quick and easy to install, using relatively little equipment and a small crew of workers. The installation procedures were basically the same as those for other types of barriers, with the exception of smaller sized panels.

Although no major problems were encountered, several concerns were noted:

1. The epoxy coated steel posts became severely scratched as the Durisol panels were slid into place. This was caused as the rough concrete sides rubbed against the posts.

2. A noticeable amount of efflorescence bled through the Durisol material. This was possibly due to improper curing of the concrete core. The panels were later sprayed with a chemical compound, which was recommended by the manufacturer, resolving this issue.

3. There was lack of uniformity in the color of the integrally pigmented panels. This inconsistency was possibly due to varying amounts of water added during batching or lack of good quality control while stain was added to a batch. This issue appeared to be resolved with the field-applied stain.

SOUND REDUCTION/ABSORPTION CHARACTERISTICS

LABORATORY TESTING

Laboratory testing of Durisol noise barrier panels was performed by Riverbank Acoustical Laboratories in 1992, to determine the Transmission Loss (TL) and Noise Reduction Coefficient (NRC) of the panels. Although the testing was not conducted as part of this research project, the results of the tests are pertinent to the evaluation of the Durisol product.

The TL is a measure of the amount of sound energy that is lost in transmission *through* a specific material and is expressed in decibels (dB). The IL is the amount of sound reduction that can be attributed to the noise barrier. As a general rule, a material with a TL of at least 10 dB greater than the desired Insertion Loss (IL) of a noise barrier should be used so that the sound reduction capability of the barrier is not compromised

Results of the laboratory tests show that the TL of Durisol panels is at least 20 dB; therefore, the Durisol panels can be expected to perform effectively in field applications where an IL of 10 dB or less is desired. For comparison purposes, Table 2 lists the TL's of several standard noise barrier materials.

Table 2: Transmission Loss (dB)

Material	Thickness	Transmission Loss
Pine	50 mm (2 in)	24
Steel	20 ga	18
Concrete	100 mm (4 in)	38

The NRC is a measure of the sound absorptive quality of a material. A material with a NRC of 0 (reflective) will reflect all of the sound energy which is transmitted towards it. A material with a NRC of 1 (absorptive) will not reflect any sound energy which is transmitted towards it.

Reflected sound from a single noise barrier with an NRC of 0 can, theoretically, increase sound levels on the opposite side of the freeway by as much as 3 dB. Furthermore, certain configurations of parallel noise barriers with an NRC of 0 may cause multiple reflections of sound energy which can reduce or, in some cases, eliminate the noise reducing effectiveness of the barrier.

Results of the laboratory tests show that the NRC for the Durisol panels is 0.80. This means that only 20% of the sound energy transmitted towards the panels was reflected under laboratory conditions. Therefore, field applications of the Durisol panels can be expected to significantly reduce sound reflections from a single noise barrier and multiple reflections from parallel barriers.

FIELD TESTING

Field testing was conducted at the site of the parallel barriers. A full report summarizing the testing, entitled *Acoustical Effectiveness of Single and Parallel Noise Barriers*, was prepared for WisDOT by the Howard Needles Tammen & Bergendoff consulting firm and is on file. A synopsis of this report is provided below.

Sound levels were simultaneously measured at three locations on the east side and two locations on the west side of I-94. The wind speeds and directions were monitored at two of the locations throughout the testing.

The data was collected during three separate time periods:

1. Before construction
2. Following partial completion of the east side barrier
3. After completion of both (parallel) barriers

Although the actual IL's at the sites varied depending on the wind speed and direction, ranges were determined from the field data that was collected following partial completion of the east side barrier and after completion of the parallel barriers.

The actual IL's can be compared to the design IL's which were determined through computer modeling. The computer model does not account for sound reflections or variations due to wind. The actual and design IL's are shown in Table 3.

Table 3: Insertion Loss (decibels)

Location	Single, Partial Barrier	Parallel Barriers	Design
East Side, Near	5 - 7	8 - 11	8
East Side, Far	4 - 7	4 - 7	6
West Side, Near	N/A	11 - 13	8
West side, Far	N/A	4 - 5	6

Three additional observations can be made from the test data:

1. Following construction of the single barrier on the east side of the freeway, a small increase (1 dB) in the sound level, under certain wind conditions, was observed at the measurement site 163 m (535 ft) west of the freeway.
2. Following construction of the parallel barriers, a small reduction (1-1.5 dB) in the IL, under certain wind conditions, was observed at the measurement site 139 m (455 ft) east of the freeway.
3. No further reduction in the IL's were observed at the measurement sites 61 m (200 ft) east and west of the freeway after the parallel barriers were completed.

Considering the results of both the field and the laboratory testing, it can be concluded that:

1. The sound reduction capability of Durisol panels, determined from laboratory testing, meets WisDOT's specifications.
2. The sound absorptive surface of Durisol panels has a noise reduction coefficient which effectively reduces reflected sound from a single noise barrier as well as multiple reflections from parallel barriers.

MATERIAL DURABILITY

Recent field inspections were conducted at both project sites. Minor surface scuffs were observed in several spots on the flat surface of the single barrier and on the fluted surface of the parallel barriers. These abrasions were very sporadic and minute. See photos on page 14. The fluted surfaces of the parallel barriers also showed minor surface abrasions and slight discoloration of the panels in the vicinities nearest the adjacent freeway. See photos on page 15. These were probably caused by the impact of snow and ice, following snowplowing activities.

None of the barriers showed signs of deterioration due to adverse weather conditions or freeze/thaw cycles. Overall, the panels were performing well and appear to have retained their color.

MAINTENANCE

The Durisol panels have required no maintenance thus far, however, they could easily be repaired or replaced if necessary. Minor repairs could be accomplished with few workers and little difficulty. A crane would be needed for major repairs requiring the removal and replacement of panels.

COSTS

WisDOT's District 2 provided results of a cost comparison of several barrier types constructed in Milwaukee County. The actual costs of the barriers, which were constructed in different years, were converted to *1994 equivalent* costs. The *1994 equivalent* total cost and the *1994 equivalent* unit cost of the Durisol noise barriers evaluated in this study are shown in Table 4.

Table 4: *1994 Equivalent* Durisol Noise Barrier Costs

Barrier Location	***1994 Equivalent* Barrier Unit Cost**
I-43	$248.43/m^2 ($23.09/ft^2)
I-94 (East side)	$212.68/m^2 ($19.76/ft^2)
I-94 (West side)	$210.70/m^2 ($19.58/ft^2)

For comparison purposes, the *1994 equivalent* average unit cost of Durisol and other barrier types constructed in Milwaukee County are shown below in Table 5. In the past several years, additional Durisol noise barriers have been constructed in Milwaukee County, the costs of which were included in computing Durisol's average unit cost.

Table 5: *1994 Equivalent* Average Unit Costs

Barrier Material	***1994 Equivalent* Average Unit Cost**
Concrete - 150 mm (6") Prestressed	$227.85/m^2 ($21.17/ft^2)
Sound Absorptive Wood	$215.84/m^2 ($20.05/ft^2)
Sound Absorptive Concrete - *Durisol*	$184.20/m^2 ($17.12/ft^2)
Metal - 22 ga Vinyl-Coated	$147.89/m^2 ($13.74/ft^2)

In fact, if the costs of the original three Durisol noise barriers evaluated in this study, which were more costly than later Durisol barriers, were excluded from the computation, the *1994 equivalent* average unit cost of a Durisol barrier would decrease to approximately $154.41/m^2 ($14.35/ft^2). Thus, the *1994 equivalent* average unit cost of Durisol is only slightly higher than a metal, non-absorptive barrier and significantly less than both a 150 mm (6") prestressed concrete, non-absorptive barrier and a sound absorptive wood barrier.

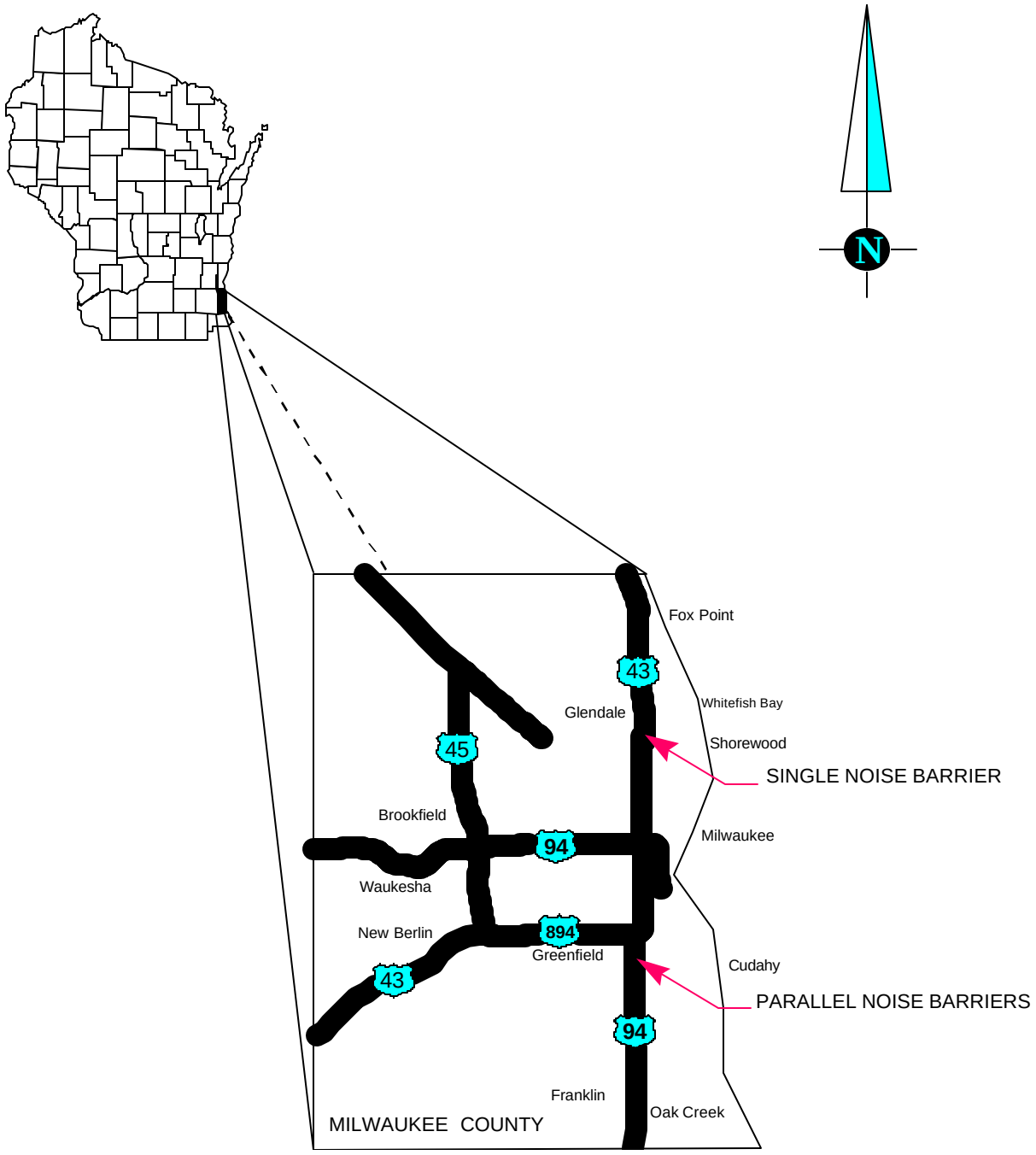
CONCLUSIONS

1. The sound reduction capability of Durisol panels, determined from laboratory testing, meets WisDOT's specifications.
2. The sound absorptive surface of Durisol panels has a noise reduction coefficient which effectively reduces reflected sound from a single noise barrier as well as multiple reflections from parallel barriers.
3. Wisconsin has been satisfied with Durisol's durability and has, over the last few years, constructed several additional Durisol noise barriers.
4. The average unit cost of Durisol barriers is competitive to other absorptive and non-absorptive sound barriers used in Milwaukee County.

RECOMMENDATIONS

Durisol Noise Barriers, manufactured by the Reinforced Earth Company, were preapproved for use on WisDOT construction projects and added to WisDOT's *Prequalified Noise Wall List* in 1994. Durisol has also met the qualification requirements of an absorptive noise wall surface, which is often specified by WisDOT. To qualify as an absorptive noise wall surface, a minimum Noise Reduction Coefficient of 0.80 on the roadway side of the barrier and 0.70 on the residential side (if applicable) are required. Based on the performance of Durisol noise barriers and the results of this study, it is recommended that WisDOT continue to accept Durisol for use as a noise barrier.

FIGURE 1: DURISOL NOISE BARRIER LOCATIONS
I-43 & I-94 - MILWAUKEE COUNTY



SINGLE DURISOL NOISE BARRIER

I-43, MILWAUKEE COUNTY

View of freeway side

View of residential side

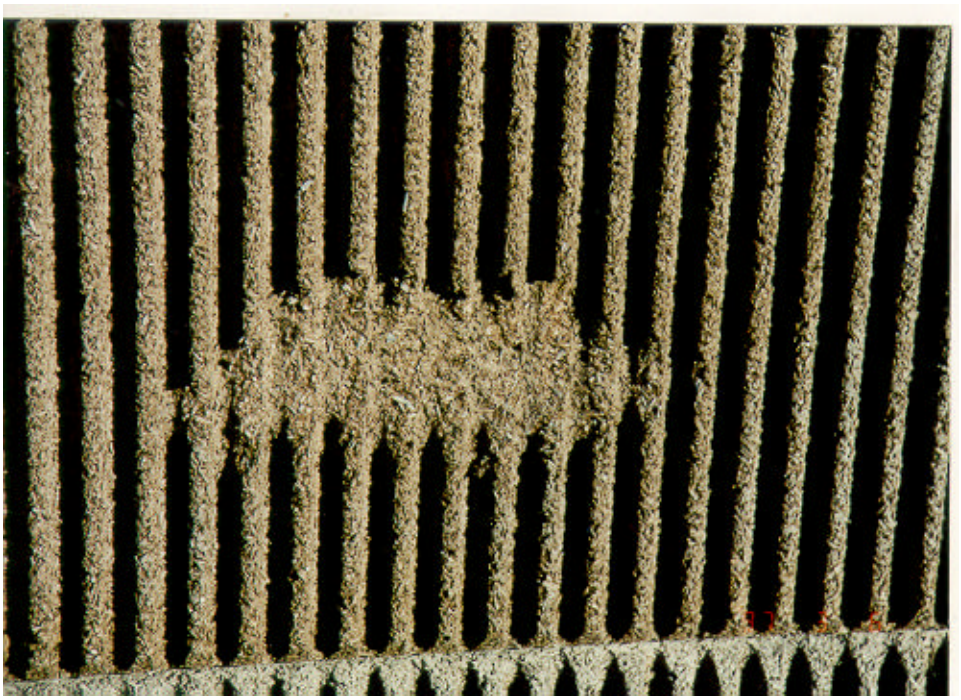
PARALLEL DURISOL NOISE BARRIERS

I-94, MILWAUKEE COUNTY

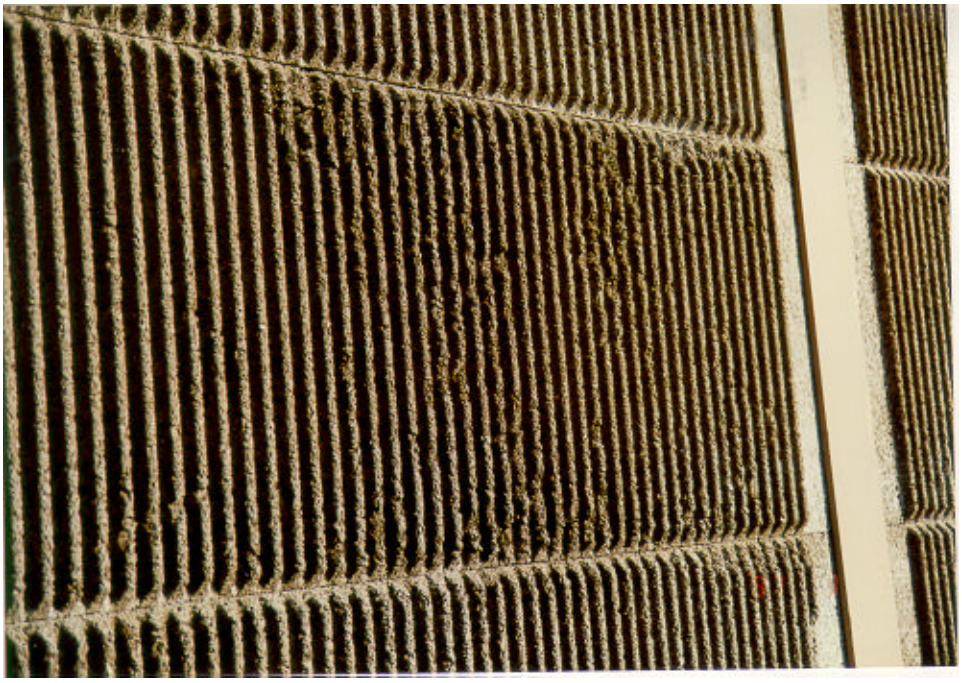
East side barrier

West side barrier

Scuff on flat surface



Scuff on fluted surface



Slight abrasions on fluted panels in the vicinity nearest the freeway

Slight discoloration of the fluted panels in the vicinity nearest the freeway